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GREENHOUSE AND FIELD FERTILIZATION OF THIN-LEAVED HUCKLEBERRY

by

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ABSTRACT

Nitrogen had a greater effect than potassium or phosphorus on thin-leaved huckleberry seedling growth in greenhouse nutrient experiments, with high levels providing the best growth. Fertilization of wild huckleberry fields with ammonium sulfate stimulated vegetative growth, especially when applied at levels of 40 and 160 pounds of nitrogen per acre. Foliar analysis showed that other nutrients were present in adequate concentrations in the field to support this increased vegetative growth.

Keywords: Huckleberry, *Vaccinium membranaceum*, nutrition (- plant physiology).

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INTRODUCTION

Fields of thin-leaved huckleberry (*Vaccinium membranaceum* Dougl.) constitute an important recreational resource. The fields, however, are shrinking in size, declining in productivity, and being used by increasing numbers of people (Minore 1972). Management plans should be devised for the most popular fields to insure their continuing existence. To date, such plans have been aimed at controlling the activities of berrypickers to minimize site deterioration. Little attention has been directed at huckleberry management, for until recently little was known about the western species of *Vaccinium*. Much more is known about the eastern highbush (*V. corymbosum* L.) and lowbush (*V. angustifolium* Ait.) blueberries.

Fertilization has been used to increase production in cultivated eastern fields for many years. Smith et al. (1946) found that using a complete fertilizer produced more vegetative growth and more and larger berries. Several authors have reported increased yields after using only a nitrogen fertilizer (Trevett 1965a, Bailey et al. 1966, Trevett et al. 1966). Trevett (1965b) found that the time of application of the nitrogen fertilizer had an effect on the response. Application before the shoots emerged caused an increase in stem growth, and application at the time of shoot dieback caused an increase in the fruit bud ratio (number of fruit buds per inch of stem) the following season. Boller (1951), working with eastern *Vaccinium* species in Oregon, found nitrogen to be the only nutrient necessary in fertilization and suggested the use of ammonium sulfate to increase the soil acidity.

The form of nitrogen is important in the eastern species. Cain (1952) found that NH_4-N was absorbed more readily than NO_3-N and that a higher nitrogen concentration was present in the leaves of plants receiving NH_4-N. Townsend (1967), using pot tests, found NH_4-N to be sufficient to maintain growth. In contrast, plants receiving NO_3-N as the only form died within 3 weeks. Plants receiving both forms together grew satisfactorily, but at a rate less than that of plants receiving NH_4-N only. Herath and Eaton (1968) found that the nitrogen concentration in the leaves increased with increasing levels of NH_4-N between 0 and 60 pounds of nitrogen per acre.

Greenhouse tests using nutrient solutions have provided additional information on the nutrition of eastern species of *Vaccinium*. Doehlert and Shive (1936) found that a high level of nitrogen and low levels of phosphorus and potassium resulted in the best vegetative growth and the highest fruit yield. They also found that a low level of nitrogen and a high level of phosphorus resulted in the poorest growth.

Foliar analysis has been used to find normal nutrient ranges and as an indicator of fertilization effects. Bailey et al. (1949) suggested that satisfactory nutrient levels for cultivated blueberries are lower than those of other fruit crops. Satisfactory foliar levels have been proposed (Ballinger and Goldston 1967, Trevett 1972). Generally accepted percentages at the start of the growing season are 1.5 to 2.0 for nitrogen, 0.08 to 0.12 for phosphorus, 0.40 to 0.55 for potassium, 0.40 to 0.65 for calcium, and 0.15 to 0.20 for magnesium. These nutrient levels change throughout the growing season (Bailey et al. 1962, Townsend and Hall 1970). Nitrogen generally declines; phosphorus follows the same trend but has a slight increase at the end of the season; potassium declines until the middle of the season and then increases to nearly the initial level.

Research reported here concerns the nutrient requirements of *V. membranaceum* Dougl. Two general approaches to this problem were used--a field

fertilization study and greenhouse pot experiments. The field study was designed to test the effect of various levels of nitrogen on vegetative growth and berry production. The greenhouse experiments were designed to ascertain the minimum nutrient levels necessary to maintain optimum growth in sand culture and the optimum pH level of the nutrient solution. In addition, a third study was carried out in the greenhouse using soil from the field and fertilizer levels equal to those used in the field to check the fertilizer effect under more optimum growth conditions.

FIELD FERTILIZATION STUDY

Methods

The field study was located in the Sawtooth huckleberry field, Mount Adams Ranger District, Gifford Pinchot National Forest, in southwestern Washington. The field occupies over 2,000 acres of gentle topography, but the area is shrinking due to brush and tree encroachment.

Forty plots of 1/100-acre were marked in a relatively uniform area. Four nitrogen fertilization treatments then were assigned within each of 10 randomized blocks. Treatments were: 0 (control), 10, 40, and 160 pounds of nitrogen per acre. Ammonium sulfate, which is the recommended fertilizer for eastern fields, was used as the source of nitrogen. The fertilizer was spread by hand in October 1972.

Growth data from the fertilizer study were gathered during late August 1973, by collecting 10 individual new shoots from each plot by mechanical sampling. These were selected by running a line with 10 knots at random intervals between the opposite corners of each plot. At each knot, the new shoot nearest the knot was clipped. After its length was measured, each twig was dried in an oven at 70° C for 5 days and weighed.

Foliar analyses were performed on the leaves of plants from both field and greenhouse studies. The leaves of each treatment group were prepared by grinding them through a 40-mesh screen and collecting the ground material in glass vials. Each open vial was placed in an oven at 70° C the afternoon before analysis. Percent nitrogen was determined by the micro-Kjeldahl method (Association of Official Agricultural Chemists 1950). Cations were determined after wet ash digestion (Fiske and Subbarrow 1925). Percent phosphorus was determined colorimetrically, and percent potassium and calcium were determined by flame spectroscopy (Chapman and Pratt 1961).

Results and Discussion

The 1973 huckleberry season was extremely poor. This is attributed to two factors. An extremely cold week in early December, before the bushes were covered with snow, killed many of the buds; and a freeze in mid-June, when the bushes were in bloom, caused heavy flower drop. As there were no berries, no data on the effect of the fertilizer treatments on berry production could be gathered.

All fertilizer treatments produced significantly longer and heavier new growth than the control treatment (table 1). The 40 and 160 pounds of nitrogen per acre produced significantly more growth than did 10 pounds. Although the 160-pound treatment showed slightly better growth than the 40-pound treatment, this difference was not statistically significant. This indicates that 40 pounds of nitrogen per acre produces a response which is nearly equal to the maximum possible response from fertilization. At levels higher than 40 pounds of nitrogen per acre, other factors may override the beneficial effect of nitrogen on huckleberry growth. For example, high levels of fertilization may produce an undesirable response from the competing vegetation, as in eastern fields.

Table 1.--*Average new growth length, ovendry weight, and foliage nutrient concentration of huckleberry bushes after field fertilization treatments*[1/]

Treatment (lb N/acre)	Length[2/]	Weight[2/]	N[2/]	P[3/]	K[3/]	Ca[3/]
	cm	*g*	- - - - - - - - -	Percent	- - - - - - - - -	
0	32.3*a*	1.39*a*	1.76*ab*	0.170*a*	0.91*a*	0.74*a*
10	41.5*b*	1.80*b*	1.71*a*	.167*a*	1.02*a*	.74*a*
40	50.2*c*	2.42*c*	1.80*b*	.160*a*	.86*a*	.68*a*
160	57.7*c*	2.79*c*	1.83*b*	.183*a*	.98*a*	.76*a*

1/ Comparable means followed by the same letter are not significantly different (0.05 level) according to Duncan's multiple range test.

2/ Each observation is the average of 10 plots.

3/ Each observation is the average of 2 plots chosen at random.

Concentration of phosphorus, potassium, and calcium in the leaves did not vary significantly among the treatments. The average percents were 0.17 for phosphorus, 0.94 for potassium, and 0.74 for calcium. All these concentrations are above those considered satisfactory for eastern blueberries (Trevett 1972). Nitrogen concentration in the leaves generally increased as the amount of fertilizer increased, but the 160-pound treatment did not differ significantly from the unfertilized control. Although the foliar nutrient concentration of plants in all treatments was similar, total nutrient uptake of plants in the higher treatments was greater because of their increased growth. This indicates that phosphorus, potassium, and calcium are present at high enough concentrations in the soil of the field area to provide for the increased growth from nitrogen fertilization without developing a deficiency in these elements. However, shortages of other nutrients may develop after the fields have been managed intensively. A close observation of the nutrient status of the bushes should therefore be maintained in order to monitor nutrient levels for potential shortages. If shortages do develop, fertilization for these other elements may be necessary. In addition, it would be worthwhile to analyze the various soil types on which the thin-leaved huckleberry grows, since soil type might affect the rate of fertilization and the elements contained in the fertilizer.

Although no data on berry production were gathered, it seems logical that berry production would be enhanced by fertilization, as is the case with eastern species. It would be valuable to verify this in the field. In addition, it might prove valuable to find out if the time of fertilizer application has an effect on the type of response, as is the case with eastern species of *Vaccinium*.

GREENHOUSE EXPERIMENTS

Methods

The greenhouse in which the studies were conducted was maintained at a 22° C day temperature and a 20° C night temperature, with no artificial illumination. Sand was used as the soil medium for the greenhouse nutrient studies. Methods outlined by Hewitt (1952) for sand preparation were generally followed. The sand was washed in a 3-percent solution of hydrochloric acid and then leached with distilled water to remove all traces of the acid. The size distribution of this sand was 12.6 percent larger than 1 mm, 52.4 percent between 0.5 and 1 mm, 27.2 percent between 0.25 and 0.5 mm, and 7.8 percent less than 0.25 mm.

The basic nutrient solution, from which all solutions used in the sand culture studies were derived, was first used by Arnon and Hoagland (1940) and is commonly known as Hoagland's solution. At full strength, it contains 18 meq/l of nitrogen, 6 meq/l of phosphorus, and 10 meq/l of potassium, as well as other necessary nutrients.

The first sand culture study was designed to determine the effect of nutrient solution pH on growth. The pH of a 1/10-strength Hoagland's solution was adjusted by adding either sulfuric acid or sodium hydroxide. Four pH treatments were replicated 10 times, using individually potted huckleberry seedlings. Treatments consisted of watering with nutrient solutions of pH 3.0, 4.0, 5.0, and 6.0. Each seedling was watered with nutrient solution three times a week and flushed with distilled water once a week, so that toxic concentrations of the nutrients could not build up in the sand. Stem length of each seedling was measured and recorded at the beginning of the study and at 2-week intervals thereafter. Ovendry weights of the seedlings were recorded at the end of the study in September 1973. Leaves of the seedlings were analyzed for nutrient concentration.

The second sand culture study was designed to determine the effect of various amounts and combinations of nitrogen, phosphorus, and potassium. Each nutrient solution treatment contained all three nutrients. The maximum (high) concentration of each was the concentration of that nutrient in full-strength Hoagland's solution. In addition, two other concentrations of 1/10-(medium) and 1/100-(low) strength Hoagland's solution were used. Concentrations of all nutrients other than nitrogen, phosphorus, and potassium were at the levels present in full-strength Hoagland's solution. By using the three nutrients together with three concentrations of each of the three named nutrients, 27 nutrient solutions were derived. All solutions were adjusted to pH 5.0 by adding sulfuric acid or sodium hydroxide. A total of 270 seedlings (10 replications of 27 treatments) was treated. Each seedling was watered with nutrient solution three times a week and flushed with distilled water once a week. The treatments were rotated around the greenhouse at 2-week intervals during the course of the study to minimize the effect of possible location differences. At the end of the study in September 1973, ovendry weight of each seedling was recorded and foliar analysis was performed on the leaves of the seedlings.

A third greenhouse study was designed to supplement the field fertilization study by demonstrating the fertilizer effect on huckleberry seedlings in a constant, favorable environment. One seedling was planted in each of 40 pots which were filled with soil from the field study area. Four treatments, each with 10 replications, were applied to these 40 pots. Fertilizer treatments of 0 (control), 10, 40, and 160 pounds of nitrogen per acre, in the form of ammonium sulfate, were applied in solution at the beginning of this study. The field soil was kept damp by watering with tapwater twice a week, but no other nutrients were added. Seedling shoot lengths were measured at the start of the study and at 2-week intervals. At the end of the study in

August 1973, after drying at 70° C for 5 days, seedling weights were determined and foliar analysis was performed on the leaves of the seedlings.

Results and Discussion

The huckleberry seedlings tolerated a wide range of pH values in the nutrient solutions, but leaf necrosis occurred in the pH 3.0 treatment, and there was less growth there than in the other three treatments (table 2). The pH 5.0 treatment had the best growth of all treatments but was not significantly better than the pH 4.0 or pH 6.0 treatments. Seedlings grown with pH 4.0, 5.0, and 6.0 treatments had relatively equal shoot growth throughout the study (fig. 1), and their root development was similar (fig. 2). Nutrient concentrations in the leaves of the seedlings of these three higher pH treatments were also similar. The nitrogen concentration of foliage from seedlings grown at pH 3.0 was slightly lower than the other three, but the potassium concentration of the pH 3.0 seedlings was over one-third higher.

Results of the nutrient study are summarized in tables 3-5. The levels of phosphorus and potassium, when analyzed individually, caused no significant seedling weight difference (table 3). However, the nitrogen levels produced highly significant differences, with the highest level of nitrogen yielding the greatest weight.

No significant interaction between phosphorus and potassium was found (table 4). The interaction of phosphorus and nitrogen was affected almost entirely by the level of nitrogen, with one exception--at the high level of nitrogen, the low level of phosphorus yielded significantly less growth than the medium or high level.

The interaction between nitrogen and potassium appears to be the most important, for significant interactions with potassium were present at all levels of nitrogen. At the high nitrogen level, the high potassium level produced significantly more growth than the medium or low levels of potassium. However, at the medium and low levels of nitrogen, the high level of potassium produced

Table 2.--*Average shoot length, ovendry weight, and foliage nutrient concentration of huckleberry seedlings after pH treatments*[1/]

Treatment (pH)	Length[2/]	Weight[2/]	N[3/]	P[3/]	K[3/]	Ca[3/]
	cm	*g*	- - - - - - -	- - *Percent*	- - - - - - -	
3.0	23.8*a*	0.63*a*	1.60	0.218	2.06	1.29
4.0	32.7*ab*	.84*ab*	1.75	.194	1.32	1.24
5.0	36.7*b*	1.19*b*	1.89	.219	1.54	1.19
6.0	34.3*ab*	.95*ab*	1.91	.206	1.47	1.19

1/ Comparable means followed by the same letter are not significantly different (0.05 level) according to Duncan's multiple range test.

2/ Average of 10 observations.

3/ Single determinations.

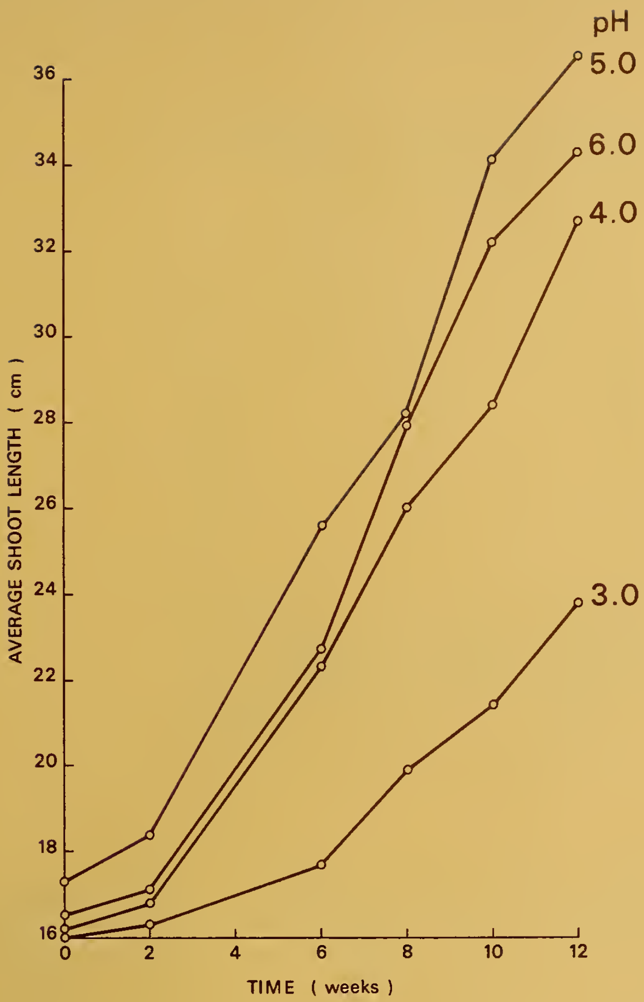

Figure 1.--Average shoot length growth of huckleberry seedlings grown at four pH levels.

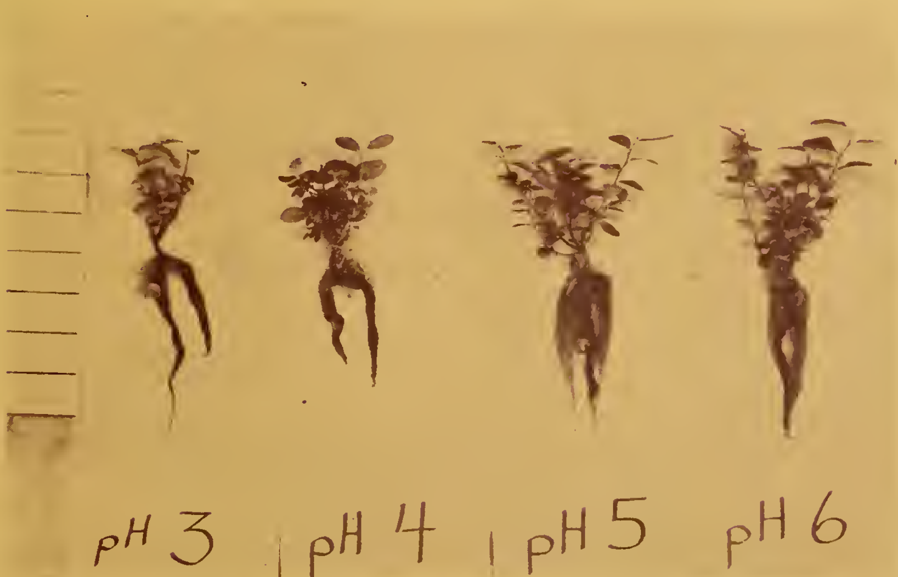

Figure 2.--Typical huckleberry seedlings at the end of the pH study. (Scale in inches)

Table 3.--*Individual element effects on average ovendry weight of huckleberry seedlings in nutrient study*[1/]

Nutrient level	N	P	K
	- - - - - - - - - - -	g	- - - - - - - - - - -
High	1.02*a*	0.66*a*	0.63*a*
Medium	.51*b*	.66*a*	.61*a*
Low	.35*c*	.55*a*	.64*a*

[1/] Comparable means followed by the same letter are not significantly different (0.05 level) according to Duncan's multiple range test. Each observation is the average of 90 seedlings.

Table 4.--*Two element interactions on average ovendry weight (grams) of huckleberry seedlings in nutrient study*[1/]

	High N	Medium N	Low N
High P	1.17*a*	0.47*b*	0.35*c*
Medium P	1.10*a*	.52*b*	.36*c*
Low P	.78*d*	.53*b*	.35*c*
	High N	Medium N	Low N
High K	1.31*a*	0.32*b*	0.26*c*
Medium K	.86*d*	.58*e*	.38*f*
Low K	.87*d*	.62*e*	.41*f*
	High P	Medium P	Low P
High K	0.63*a*	0.73*a*	0.56*a*
Medium K	.67*a*	.60*a*	.55*a*
Low K	.68*a*	.65*a*	.58*a*

[1/] Comparable means followed by the same letter are not significantly different (0.05 level) according to Duncan's multiple range test. Each observation is the average of 30 seedlings.

Table 5.--*Percentage by dry weight of elements in seedling foliage after nutrient treatments*[1/]

Nutrient level	N	P	K
	- - -	- - - - *Percent* - - - -	- - - -
High	2.10*a*	0.206*a*	2.54*a*
Medium	1.21*a*	.156*b*	1.07*b*
Low	.76*c*	.144*b*	1.04*b*

[1/] Comparable means followed by the same letter are not significantly different (0.05 level) according to Duncan's multiple range test. Each observation is the average of 9 treatments.

significantly less growth than the medium or low levels. The cause of this adverse effect is not apparent, but a possible explanation is that the huckleberry plants take up all the potassium that is available to them. Concentration of potassium in the plants may then reach a level that causes a nutrient imbalance if adequate nitrogen is not available. Therefore, additions of potassium by fertilization should be avoided unless potassium has been found to be the limiting factor in an individual field.

Each nitrogen level produced a significantly different foliar nitrogen concentration (table 5), with the high level having the highest concentration. The high levels of phosphorus and potassium in the solutions also produced significantly higher concentrations of these elements in the seedling leaves. However, the medium and low phosphorus and potassium levels did not produce significantly different concentrations in the leaves. No interaction between elements was found in relation to foliar nutrient concentration.

Results of the greenhouse study of field soil fertilization are summarized in table 6. The unfertilized control and 10 pounds of nitrogen per acre were not significantly different. However, the higher fertilization treatments produced significantly higher dry weight than the two low-level treatments. The increase in shoot length for the 40-pound and 160-pound treatments was more rapid and longer lasting than for the lower levels (fig. 3). Root development of the seedlings also was better at the two highest levels of fertilization (fig. 4). The highest nitrogen level produced the greatest growth. Seedlings fertilized at this level were significantly heavier than those given 40 pounds of nitrogen per acre.

None of the seedlings potted in soil from the field were harvested until the seedlings in the 160-pound treatment had stopped growing. Greenhouse

Table 6.--*Average shoot length, ovendry weight, and foliage nutrient concentration of huckleberry seedlings grown on fertilized field soil in the greenhouse*[1/]

Treatment (lb N/acre)	Length[2/]	Weight[2/]	N[3/]	P[3/]	K[3/]	Ca[3/]
	cm	*g*	Percent			
0	12.2*a*	0.54*a*	0.71	0.102	0.41	0.94
10	13.7*ab*	.62*a*	1.03	.120	.58	1.19
40	17.8*bc*	1.06*b*	1.16	.121	.64	1.26
160	23.0*c*	1.54*c*	1.43	.128	.83	1.29

1/ Comparable means followed by the same letter are not significantly different (0.05 level) according to Duncan's multiple range test.

2/ Each observation is the average of 10 seedlings.

3/ Single determinations.

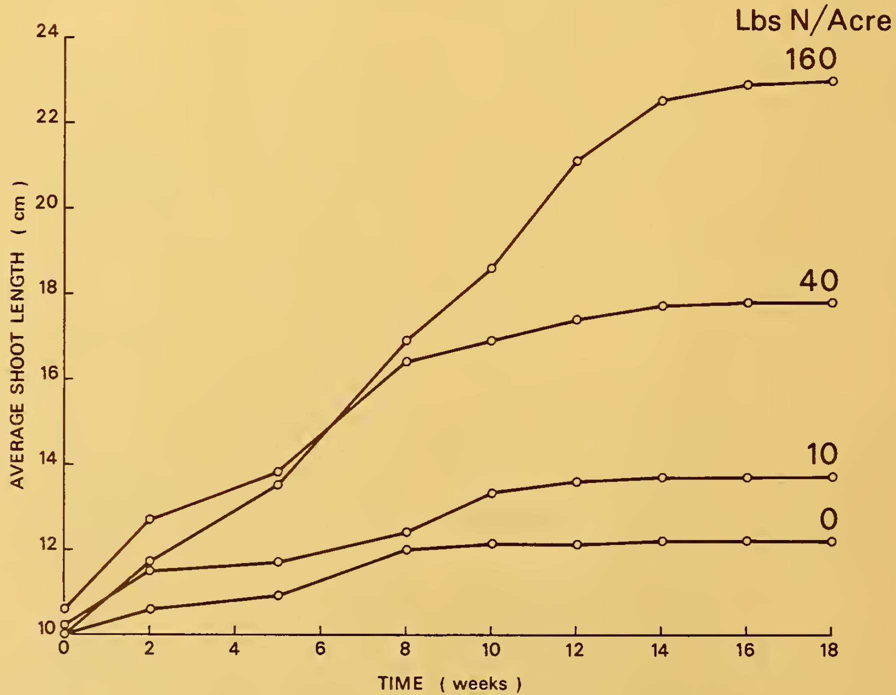

Figure 3.--Average shoot length growth of huckleberry seedlings grown on fertilized field soil in the greenhouse.

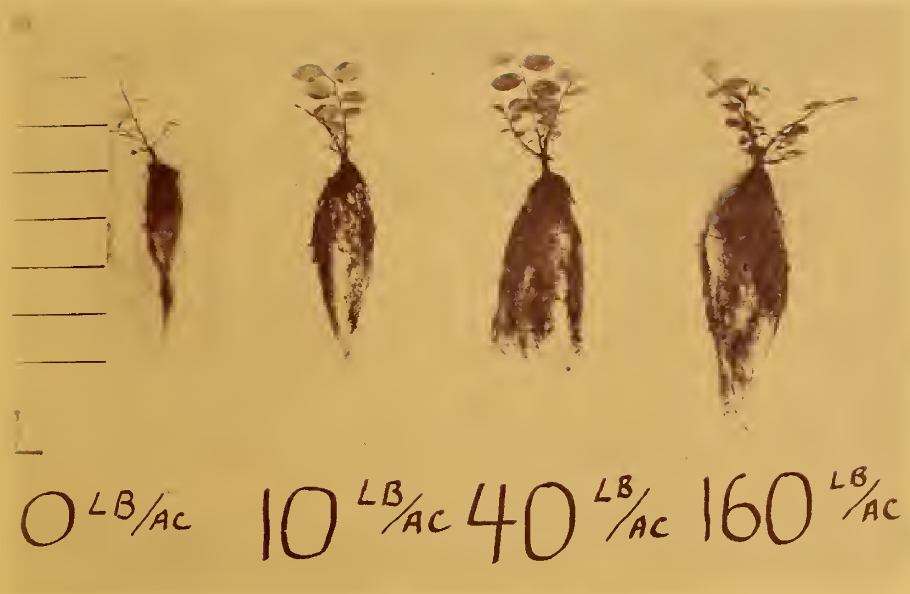

Figure 4.--Typical huckleberry seedlings after greenhouse growth on field soil fertilized with nitrogen. (Scale in inches)

conditions may have permitted a dilution of the nutrients in the leaves of the seedlings, and the foliar concentrations of nitrogen, phosphorus, and potassium were all lower than those found in the field.

All these studies indicate that growth of the thin-leaved huckleberry is increased by ammonium nitrogen fertilizer. The ammonium could be supplied by ammonium sulfate, as it was in this study, or by urea or other ammonium-containing fertilizers. It should be applied at a rate of 40 to 160 pounds of nitrogen per acre for maximum increase in growth.

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